BMJ open

Mental health effects from urban bed bug infestation (Cimex lectularius L.): a cross sectional study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000838
Article Type:	Research
Date Submitted by the Author:	06-Jan-2012
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Primary Subject Heading:	Mental health
Secondary Subject Heading:	Occupational and environmental medicine, Public health
Keywords:	bed bugs, sleep disturbances, anxiety, depression, MENTAL HEALTH

ARTICLE TYPE: Research article

TITLE: Mental health effects from urban bed bug infestation (Cimex lectularius L.): a cross sectional study.

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KEY WORDS: bed bugs, anxiety, sleep disturbance, depression, mental health

WORD COUNT: 1221 (excluding title page, abstract, references, figures and tables)

ABSTRACT

Objective To assess whether bed bug infestation was linked to sleep disturbances and symptoms of anxiety and depression.

Design exploratory cross-sectional study.

Setting Convenience sample of tenants recruited in apartment complexes from Montreal, Canada.

Participants 39 bed bug-exposed tenants were compared to 52 unexposed tenants.

Main outcome measures The effect of bed bug exposed tenants on sleep disturbances, anxiety and depression symptoms measured using the PSQI(5) (Pittsburgh Sleep Quality Index, 5th subscale), GAD-7 (Generalized Anxiety Disorder 7-item scale) and PHQ-9 (Patient Health Questionnaire, 9-item), respectively.

Results In adjusted models, bed bug infestation was strongly associated with measured anxiety symptoms [OR(95% CI)=4.8 (1.5-14.7)] and sleep disturbance [OR(95% CI)=5.0 (1.3-18.8)]. There was a trend to report more symptoms of depression in the bed bug infested group, although this finding was not statistically significant [(OR(95% CI)=2.5(0.8-7.3)].

Conclusions These results suggest that individuals exposed to bed bug infestations are at risk of experiencing sleep disturbance and of developing symptoms of anxiety and possibly depression. Greater clinical awareness of this problem is needed in order for patients to receive appropriate mental health care. These findings highlight the need for undertaking of deeper inquiry, as well as greater collaboration between medical professionals, public health and community stakeholders.

ARTICLE SUMMARY

Article focus

- Infestations with the common bed bug (*Cimex lectularius L.)* have become problematic in many cities.
- No epidemiologic studies currently exist on the mental health impacts of bed bug infestations.
- In this exploratory cross-sectional analysis, we assessed whether bed bug infestations were linked to sleep disturbances and symptoms of anxiety and depression among tenants in Montreal, Quebec.

Key messages

- This study suggests that individuals exposed to bed bugs may be at risk of experiencing sleep disturbance and of developing anxious and possibly depressive symptoms.
- Appropriate control of bed bug is required to manage the situation and its potential health impacts.

Strength and limitations of this study

- The convenience sample presents a risk for selection bias
- There is a possibility of misclassification biases due to self report even though the Cronbach α values calculated from our data showed remarkable consistency with literature values for the original instruments.
- These results, although compelling, are cross sectional in nature and follow-up studies are required.

INTRODUCTION

Anecdotal and historical evidence suggests that infestations with the common bed bug (*Cimex lectularius* L.) can cause profound emotional and psychological effects.[1] Field workers and pest managers in Montreal,[2] Toronto,[3] and in 43 countries around the globe surveyed by the NPMA (National Pest Management Association) have observed psychological distress among infested individuals.[4] There are reports of people resorting to dangerous methods in order to rid their dwellings of bed bugs,[5] and recently, Goddard and de Shazo highlighted that comments posted on bed bug-related websites revealed symptoms of PTSD (Post Traumatic Stress Disorder).[6] However, there is currently no original published epidemiologic data available on the mental health impact of bed bug infestations. The objective of this study was to conduct an exploratory cross-sectional analysis comparing individuals living with and without bed bug infestations using three standardized clinical mental health measures.

METHODS

Data collection and measures

The present cross sectional study is based on data provided by a convenience sample of 91 tenants recruited from two Montreal apartment complexes who participated in public health interventions targeting unfit housing conditions led by the Montreal Public Health Department and their community partners between January and June 2010. All participants agreed to have the data they provided be used for research purposes. Physicians and nurses familiar with unfit housing conditions and infestations collected all data. Culturally and linguistically competent translators were available and all questionnaire material was available in English, French and Spanish. Ethical approval

was provided by the research ethics committee of the Montreal agency for health and social services. The research has conformed to the principles embodied in the Declaration of Helsinki.

Data were obtained from an intervention health questionnaire. Symptoms of depression and anxiety were evaluated using the Brief Patient Health Questionnaire Mood Scale (PHQ-9)[7] and the Generalized Anxiety Disorder Screener (GAD-7)[8] which are based on criteria from the DSM-IV and DSM-IV-TR, respectively. Sleep disturbances were measured using questions 1-8 (5^{th} subscale) of the Pittsburgh Sleep Quality Index.[9] Bed bugs exposure status was initially determined by self-report; participants were asked to point to the culprit insect on an identification tool containing pictures of bed bugs and other commonly found insects in Montreal apartment buildings. Details related to infestation (onset, corrective measures taken) were recorded. This subjective evidence was supported by objective dermatological and/or environmental evidence of infestation when available (**figure 1**). Individuals for whom objective evidence was unavailable and who reported that bed bugs had not been seen in the dwelling for >30days were classified as unexposed (**figure 2**). Other variables from the health questionnaire include demographic features, history of chronic medical and psychiatric conditions (>6 months in duration), experience of a particularly stressful event within the last year (yes/no variable) as well as environmental exposure information other than that pertaining to bed bugs (number of inhabitants, exposure to cockroaches).

Statistical analysis

Chi-square analyses were used to distinguish characteristics particular to the bed bug exposed group as compared to the unexposed group. Scores for the three instruments were dichotomized into 'present/absent'. Scores corresponding to symptoms 'present' were: 10 and over on the PHQ-9 out of 27, (moderate symptoms of depression or worse), 5 and over on the GAD-7 out of 21(mild symptoms of anxiety or worse) and 10 and over out of 27 on the PSQI 5th subscale. For any given participant, data from the GAD-7 or PHQ-9 were disregarded if 3 or more items were left blank. Missing values for these scales were imputated if the number of missing responses was less than 3.

Multivariable logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) for an association between bed bug infestation exposure and 'present' mental health symptoms. Models were initially run for exposure status alone, then adjusted for sex and age. The PHQ-9 and GAD-7 models were adjusted as well for psychiatric diagnosis and number of inhabitants. The GAD-7 model was additionally adjusted for cockroaches in the dwelling. Adjusted model parameters did not change by more than 10% with the addition of employment status, perceived sufficient means, civil status, medical diagnoses or experience of a stressful event within the last year. Final models were re-run without 10 individuals for whom there were no objective evidence to support or refute their (previous) self report. Cronbach α values were calculated to measure the internal consistency of the psychometric tools [GAD-7, PHQ-9 and PSQI(5)]. Analyses were performed using SPSS 12.0.2 for Windows (SPSS 1989-2003).

RESULTS

There were 39 individuals exposed to bed bugs and 52 unexposed individuals (**Figure 2**). Individuals exposed to bed bug infestations did not differ significantly from those unexposed on the characteristics shown in **Table 1** except for 'number of individuals living in the dwelling' and 'self-reported cockroach exposure'. Pearson Chi-Square scores for the univariate associations between bed bug infestation status and the dependent variables were significant at $p<0.05$ for the GAD-7 and PSQI(5) but not for the PHQ-9.

Table 1 Characteristics and instrument scores of participants according to bed bug infestation exposure status.

Characteristics	Exposed to bed bug infestation (%)	Unexposed (%)	N**
Sex			
Male	50	50	38
Female	38	62	53
Age			
≤36 years	48	52	48
≥37 years	37	63	43
Education			
Less than high school	41	59	17
High school or more	38	62	60
Employment status			
Employed	42	58	36
Unemployed	44	56	55
Legally married			
Yes	42	58	50
No	44	56	41
Perceived sufficient means			
Yes	46	54	39
No	42	58	48
Stressful event in last year			
Yes	43	57	58
No	42	58	33

Psychiatric diagnosis			
None	43	57	76
1+	44	56	9
Medical diagnosis			
None	53	48	40
1+	35	65	51
Number of inhabitants *			
1-2	20	80	25
3+	52	48	65
Cockroaches in dwelling *			
Present	50	50	72
Absent	16	84	19
Anxiety symptoms (GAD7) *			
Present	55	45	31
Absent	32	68	56
Depressive symptoms (PHQ9)			
Present	52	48	27
Absent	37	63	60
Sleep Disturbance (PSQI-5) *			
Present	71	29	14
Absent	40	60	68
Total			91

* These variables differed significantly for the exposure groups on Pearson Chi-Square analysis $p<0.05$, two-sided test.
** May not total due to missing data.

Results of the logistic regression models are displayed in **Table 2.** In both unadjusted and adjusted models, the association between anxiety symtoms and bed bug infestation status was statistically significant [OR(95%CI) adjusted model = 4.8 (1.5-14.7)]. A statistically significant association was also found for sleep disturbance [OR(95%CI) adjusted model = 5.0 (1.3-18.8)]. There was a statistically non-significant association observed between depressive symptoms and bed bug infestation [OR(95%CI) adjusted model = 2.5 (0.8-7.3)]. Sensitivity analysis as outlined above did not alter results.

The Cronbach α values calculated from the data for the GAD-7, PHQ-9 and PSQI(5) were found to be 0.86, 0.83 and 0.69, respectively.

Table 2 Odds ratios (OR) and 95% confidence intervals (CI) for the associations between bed bug infestation exposure and mental health symptoms

	Unadjusted OR [95% CI]	Fully adjusted OR [95% CI]*
PSQI(5)	3.80 [1.10, 13.35]	5.00 [1.30, 18.80]
GAD-7	2.56 [1.04, 6.32]	4.75 [1.54, 14.70]
PHQ-9	1.86 [0.74, 4.67]	2.48 [0.84, 7.30]

* All models were adjusted for sex and age. GAD-7 and PHQ-9 were further adjusted for psychiatric diagnosis and number of inhabitants. GAD-7 was additionally adjusted for cockroaches in dwelling.

DISCUSSION

Our study showed that anxiety symptoms and sleep disturbances were significantly more likely to occur among individuals exposed to bed bug infestations. The association between exposure and depressive symptoms occurred in the expected direction, but was non-significant at the level of $p<0.05$.

To our knowledge, this study is the first to quantitatively explore the mental health impact of bed bug infestations. Literature on the mental health effects of infestation with biting arthropods is scant, but some anecdotal evidence is available for pigeon fleas[10] and headlice.[11] The dermatologic literature details other pruritic skin conditions such as psoriasis and atopic dermatitis and their consequences on sleep[12] and mental health.[13]

This study has several limitations. The convenience sample presents a risk for selection bias, and there is a possibility of misclassification due to self report in the intervention context. However, the Cronbach α values calculated from the totality of our data showed remarkable consistency with literature values for the original instruments. Cronbach α values in our study for the GAD-7, PHQ-9 and PSQI(5) were 0.86, 0.83 and 0.69, respectively with corresponding literature values of 0.92,[8] 0.86-0.89,[7] and 0.70-0.78,[14] respectively.

These results, although compelling, are cross sectional in nature and follow-up studies are required. A 'pre-post' intervention approach would be appropriate in this situation as there is an ethical imperative to treat the dwellings of patients in addition to their symptoms.

Clinicians should be aware of the impacts bed bug infestations can have on patients, particularly those from vulnerable populations. Rapid implementation of policies to control the infestation based on evidence-based removal and prevention practices will be required to manage the situation and its potential societal impacts. This is a considerable task, and one could envision success if a multidisciplinary approach is used with collaboration between municipal authorities, medical professionals, public health, entomologists and community stakeholders.

CONTRIBUTORSHIP STATEMENT

All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors accept responsibility for the content of this manuscript. The article is not under consideration for publication elsewhere. The authors reviewed this manuscript and all agree that the work is ready for submission. The study was conceptualized and designed by Stephanie Susser, Stéphane Perron, Michel Fournier, Louis Jacques, Geoffroy Denis and Pasquale Roberge. The data was acquired by Stephanie Susser, Stéphane Perron, Louis Jacques and Geoffroy Denis. Statistical analysis was performed by Stephanie Susser, Stéphane Perron and Michel Fournier. The data was analyzed and interpreted by all authors. The manuscript was drafted by Stephanie Susser and revised by all authors.

ACKNOWLEDGEMENTS

Michael Potter and Jerome Goddard revised the article and gave relevant comments regarding manuscript preparation. Benoît Côté and Jérome Coulombe, both dermatologists practicing in Montreal gave helpful comments on the content of figure 1. Isabelle Mondou gave comments on the study and the manuscript. Nassima Chirane offered comments on the study. Valérie Clayman helped edit the manuscript.

COMPETING INTERESTS AND FUNDING

The work presented in this manuscript was supported financially by institutions with no competing interests. None of the authors have any competing interests to declare.

LICENCE FOR PUBLICATION

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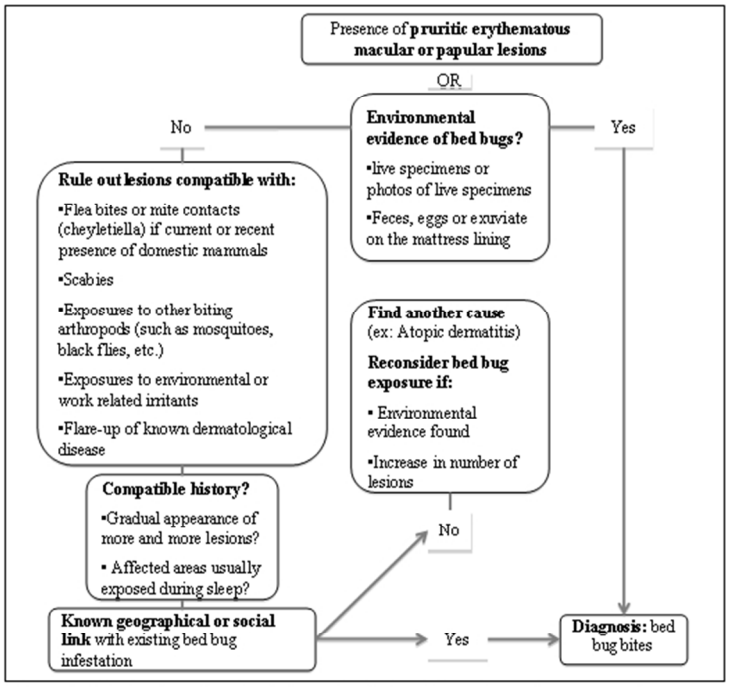
FIGURE LEGEND

Figure 1. Algorithm for attribution of a diagnosis of bed bug infestation based on presence of characteristic lesions and environmental evidence

Figure 2. Participant flowchart



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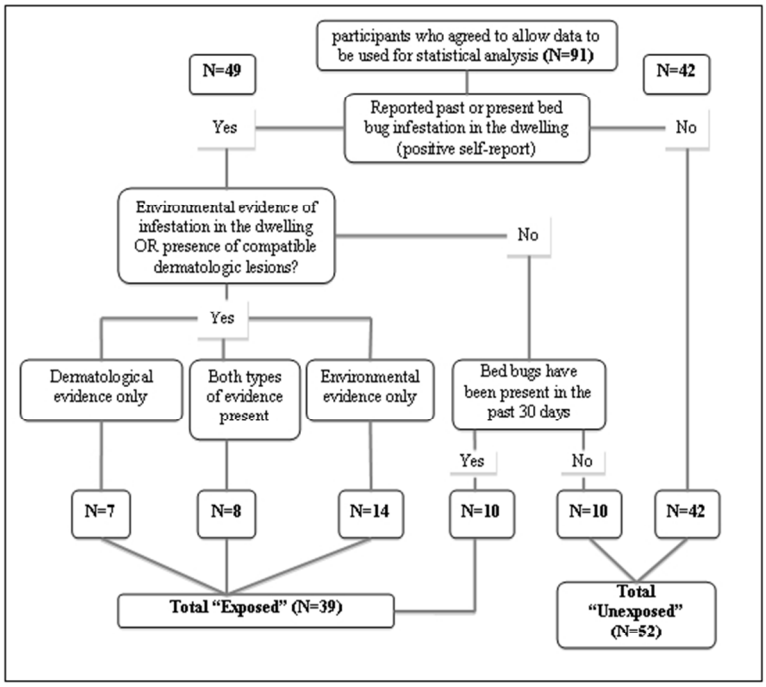

Figure 2: Participant flowchart

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 7 figure 2
		(b) Give reasons for non-participation at each stage	Page 7 figure 2
		(c) Consider use of a flow diagram	Figure 2
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7 table 1
		(b) Indicate number of participants with missing data for each variable of interest	Page 7 table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Page 7 table 1
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 8 table 2
		(*b*) Report category boundaries when continuous variables were categorized	Page 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 10
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ open

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Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2012-000838.R1
Article Type:	Research
Date Submitted by the Author:	17-Apr-2012
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Strength and limitations of this study

- The convenience sample presents a risk for selection bias
- There is a possibility of misclassification biases due to self report even though the Cronbach α values calculated from our data showed remarkable consistency with literature values for the original instruments.
- These results are cross sectional in nature and follow-up studies are required.

INTRODUCTION

Adult bed bugs are 4-6mm long, oval and flattened insects that feed on human blood. Feeding sessions typically last fifteen minutes and are followed by the departure of the bug toward its harborage site. Once fed, bed bugs do not remain attached to their prey.[1] Bed bug bites, like mosquito bites are associated with local cutaneous allergic reactions.[2] To date, there have been no reports of infectious disease transmission via bed bug bites.[2,3] Bed bugs can be exterminated rapidly but extermination techniques are complex. In some settings bed bug infestation may become chronic.[4]

Anecdotal and historical evidence suggests that infestation by the common bed bug (*Cimex lectularius* L.) may be a stressor that has an emotional and psychological effect.[3] Field workers and pest control managers in Montreal,[5] Toronto,[4] and in 43 countries around the globe surveyed by the NPMA (National Pest Management Association) have observed psychological distress among individuals living with infestation.[6] There are reports of people resorting to dangerous methods in order to rid their dwellings of bed bugs.[7] Recently, Goddard and de Shazo noted that comments posted on bed bug-related websites revealed symptoms of PTSD (Post Traumatic Stress Disorder).[8] None of these studies, however, were performed in a clinical setting and there is currently no original published epidemiologic data available on the mental health impact of bed bug infestation. The objective of this study was to conduct an exploratory cross-sectional analysis comparing individuals living with and without bed bug infestations using three standardized clinical mental health measures.

METHODS

Data collection and measures

Unfit housing conditions due to water infiltration, mould and vermin infestation are frequently reported to the Montreal Public Health Department (MPH). Decision to intervene in such situations is taken by the environmental health team which includes physicians and an experienced hygienist. The aim of field intervention, when mandated, is to produce recommendations for remediation of the buildings involved and to ensure healthcare for tenants who may require attention. However, relocation of tenants to other housing complexes is only recommended in cases where tenants experience a significant negative health impact due to water infiltration. Participants were recruited from the two Montreal apartment complexes who were subject to public health interventions targeting unfit housing conditions led by the Montreal Public Health Department and their community partners between January and June 2010. This cross sectional study is based on data provided by a convenience sample of 91 tenants recruited. All participants agreed to allow the data they provided be used for research purposes.

Physicians and nurses familiar with unfit housing conditions and infestations collected all data. Culturally and linguistically competent translators were available and all questionnaire material was available in English, French and Spanish. Ethical approval was provided by the research ethics committee of the Montreal Agency for Health and Social Services. The research has conformed to the principles embodied in the Declaration of Helsinki.

Data were obtained from an intervention health questionnaire. Symptoms of depression and anxiety were evaluated using the Brief Patient Health Questionnaire Mood Scale (PHQ-9)[9] and the Generalized Anxiety Disorder Screener (GAD-7)[10] which are based on criteria from the DSM-IV and DSM-IV-TR, respectively. Sleep disturbances were measured using questions 1-8 (5^{th} subscale) of the Pittsburgh Sleep Quality Index.[11] Bed bug exposure status was initially determined by self-report; participants were asked to point to the culprit insect on an identification tool containing pictures of bed bugs and other commonly found insects in Montreal apartment buildings. Details related to infestation (onset, corrective measures taken) were recorded. This subjective evidence was supported by objective dermatological and/or environmental evidence of infestation when available (**figure 1**). Individuals with past bed bug exposure - but who reported that bed bugs had not been seen in the dwelling for >30days - were classified as unexposed (**figure 2**). Other variables from the health questionnaire include demographic features, history of chronic medical and psychiatric conditions (>6 months in duration), experience of a particularly stressful event within the last year (yes/no variable) as well as environmental exposure information other than that pertaining to bed bugs (number of inhabitants, exposure to cockroaches).

Statistical analysis

Chi-square analyses were used to distinguish characteristics particular to the bed bug exposed group as compared to the unexposed group. Scores for the three instruments were dichotomized into 'present/absent'. Scores corresponding to symptoms 'present'

were: 10 and over on the PHQ-9 out of 27, (moderate symptoms of depression or worse), 5 and over on the GAD-7 out of 21(mild symptoms of anxiety or worse) and 10 and over out of 27 on the PSQI 5th subscale. For any given participant, data from the GAD-7 or PHQ-9 were disregarded if 3 or more items were left blank. Missing values for these scales were replaced with the mean scores of the other subjects items response if the number of missing responses was less than 3.

Multivariable logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) for an association between bed bug infestation exposure and anxiety, depressive symptoms and sleep disturbance. Models were initially run for exposure status alone, then adjusted for sex and age. The PHQ-9 and GAD-7 models were adjusted as well for psychiatric diagnosis and number of inhabitants. The GAD-7 model was additionally adjusted for cockroaches in the dwelling. Adjusted model parameters did not change by more than 10% with the addition of employment status, perceived sufficient means, civil status, medical diagnoses or experience of a stressful event within the last year. Final models were re-run without 10 individuals for whom there were no objective evidence to support or refute their (previous) self report. Cronbach α values were calculated to measure the internal consistency of the psychometric tools [GAD-7, PHQ-9 and PSQI(5)]. Analyses were performed using SPSS 12.0.2 for Windows (SPSS 1989-2003).

RESULTS

There were 39 individuals exposed to bed bugs and 52 unexposed individuals (**Figure 2**). Exposed and unexposed individuals were found in both housing complexes. Individuals exposed to bed bug infestation did not differ significantly from those unexposed on the characteristics shown in **Table 1** except for 'number of individuals living in the dwelling' and 'self-reported cockroach exposure'. Pearson Chi-Square scores for the univariate associations between bed bug infestation status and the dependent variables were significant at $p<0.05$ for the GAD-7 and PSQI(5) but not for the PHQ-9.

Table 1 Characteristics and instrument scores of participants according to bed bug infestation exposure status.

Characteristics	Exposed to bed bug infestation (%)	N**
Sex		
Male	50	38
Female	38	53
Age		
≤36 years	48	48
≥37 years	37	43
Education		
Less than high school	41	17
High school or more	38	60
Employment status		
Employed	42	36
Unemployed	44	55
Legally married		
Yes	42	50
No	44	41
Perceived sufficient means		
Yes	46	39
No	42	48
Stressful event in last year		
Yes	43	58
No	42	33
Psychiatric diagnosis		
None	43	76

1+	44	9
Medical diagnosis		
None	53	40
1+	35	51
Number of inhabitants *		
1-2	20	25
3+	52	65
Cockroaches in dwelling *		
Present	50	72
Absent	16	19
Anxiety symptoms (GAD7) *		
Present	55	31
Absent	32	56
Depressive symptoms (PHQ9)		
Present	52	27
Absent	37	60
Sleep Disturbance (PSQI-5) *		
Present	71	14
Absent	40	68
Total		91

* These variables differed significantly for the exposure groups on Pearson Chi-Square analysis $p<0.05$, two-sided test.
** May not total due to missing data.

Results of the logistic regression models are displayed in **Table 2.** In both unadjusted and adjusted models, the association between anxiety symtoms and bed bug infestation status was statistically significant [OR(95%CI) adjusted model = 4.8 (1.5-14.7)]. A statistically significant association was also found for sleep disturbance [OR(95%CI) adjusted model = 5.0 (1.3-18.8)]. There was a statistically non-significant association observed between depressive symptoms and bed bug infestation [OR(95%CI) adjusted model = 2.5 (0.8-7.3)]. Sensitivity analysis as outlined above did not alter results.

The Cronbach α values calculated from the data for the GAD-7, PHQ-9 and PSQI(5) were found to be 0.86, 0.83 and 0.69, respectively.

Table 2 Odds ratios (OR) and 95% confidence intervals (CI) for the associations between bed bug infestation exposure and mental health symptoms

	Unadjusted OR [95% CI]	Fully adjusted OR [95% CI]*
PSQI(5)	3.80 [1.10, 13.35]	5.00 [1.30, 18.80]
GAD-7	2.56 [1.04, 6.32]	4.75 [1.54, 14.70]
PHQ-9	1.86 [0.74, 4.67]	2.48 [0.84, 7.30]

* All models were adjusted for sex and age. GAD-7 and PHQ-9 were further adjusted for psychiatric diagnosis and number of inhabitants. GAD-7 was additionally adjusted for cockroaches in dwelling.

DISCUSSION

Our study showed that anxiety symptoms and sleep disturbances were significantly more likely to occur among individuals exposed to bed bug infestation. The association between exposure and depressive symptoms occurred in the expected direction, but was non-significant at the level of $p<0.05$.

To our knowledge, this study is the first to quantitatively explore the anxiety symptoms, depressive symptoms and sleep disturbance associated with bed bug infestations. Literature on anxiety and depressive symptoms and sleep disturbance associated with infestation with biting arthropods is scant, but some anecdotal evidence exists that infestation with pigeon fleas[12] and headlice can have a negative effect on sleep.[13] The dermatologic literature details other pruritic skin conditions such as psoriasis and atopic dermatitis and their consequences on sleep[14] and mental health.[15]

This study has several limitations. The convenience sample presents a risk for selection bias, the magnitude of which is attenuated by the fact that both exposed and non exposed subjects lived in the same apartment complexes. There is a possibility of misclassification due to self report in the intervention context. However, the Cronbach α values calculated from the totality of our data showed remarkable consistency with literature values for the original instruments. Cronbach α values in our study for the GAD-7, PHQ-9 and PSQI(5) were 0.86, 0.83 and 0.69, respectively with corresponding literature values of 0.92,[10] 0.86-0.89,[9] and 0.70-0.78,[16] respectively.

These results are cross sectional in nature and follow-up studies are required. A 'pre-post' intervention approach would be appropriate in this situation as there is an ethical imperative to treat the dwellings of patients in addition to their symptoms. Such an approach would allow us to evaluate changes in reported symptoms after the bed bugs have been eradicated in the dwelling and the stressor thus removed.

Clinicians should be aware of the impacts bed bug infestations can have on patients, particularly those from vulnerable populations. Rapid implementation of policies to control the infestation based on evidence-based removal and prevention practices will be required to manage the situation and its potential societal impacts. This is a considerable task, and one could envision success if a multidisciplinary approach is used with collaboration between municipal authorities, medical professionals, public health, entomologists and community stakeholders.

CONTRIBUTORSHIP STATEMENT

All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors accept responsibility for the content of this manuscript. The article is not under consideration for publication elsewhere. The authors reviewed this manuscript and all agree that the work is ready for submission. The study was conceptualized and designed by Stephanie R. Susser, Stéphane Perron, Michel Fournier, Louis Jacques, Geoffroy Denis and Pasquale Roberge. The data was acquired by Stephanie R. Susser, Stéphane Perron, Louis Jacques and Geoffroy Denis. Statistical analysis was performed by Stephanie R. Susser, Stéphane Perron and Michel Fournier. The data was analyzed and interpreted by all authors. The manuscript was drafted by Stephanie R. Susser and revised by all authors.

ACKNOWLEDGEMENTS

Michael Potter and Jerome Goddard revised the article and gave relevant comments regarding manuscript preparation. Benoît Côté and Jérome Coulombe, both dermatologists practicing in Montreal gave helpful comments on the content of figure 1. Isabelle Mondou gave comments on the study and the manuscript. Nassima Chirane offered comments on the study. Valérie Clayman helped edit the manuscript.

COMPETING INTERESTS AND FUNDING

The work presented in this manuscript was supported financially by the Direction de santé publique de Montréal with no competing interests. None of the authors have any competing interests to declare.

LICENCE FOR PUBLICATION

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FIGURE LEGEND

Figure 1. Algorithm for attribution of a diagnosis of bed bug infestation based on presence of characteristic lesions and environmental evidence

Figure 2. Participant flowchart

ARTICLE TYPE: Research article

TITLE: Mental health effects from urban bed bug infestation (Cimex lectularius L.): a cross sectional study.

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KEY WORDS: bed bugs, anxiety, sleep disturbance, depression, mental health

WORD COUNT: ~~1221~~ 1775 (excluding title page, abstract, references, figures and tables)

ABSTRACT

Objective To assess whether bed bug infestation was linked to sleep disturbances and symptoms of anxiety and depression.

Design exploratory cross-sectional study.

Setting Convenience sample of tenants recruited in apartment complexes from Montreal, Canada.

Participants 39 bed bug-exposed tenants were compared to 52 unexposed tenants.

Main outcome measures The effect of bed bug exposed tenants on sleep disturbances, anxiety and depression symptoms measured using the PSQI(5) (Pittsburgh Sleep Quality Index, 5th subscale), GAD-7 (Generalized Anxiety Disorder 7-item scale) and PHQ-9 (Patient Health Questionnaire, 9-item), respectively.

Results In adjusted models, bed bug infestation was strongly associated with measured anxiety symptoms [OR(95% CI)=4.8 (1.5-14.7)] and sleep disturbance [OR(95% CI)=5.0 (1.3-18.8)]. There was a trend to report more symptoms of depression in the bed bug infested group, although this finding was not statistically significant [(OR(95% CI)=2.5(0.8-7.3)].

Conclusions These results suggest that individuals exposed to bed bug infestations are at risk of experiencing sleep disturbance and of developing symptoms of anxiety and possibly depression. Greater clinical awareness of this problem is needed in order for patients to receive appropriate mental health care. These findings highlight the need for undertaking of deeper inquiry, as well as greater collaboration between medical professionals, public health and community stakeholders.

ARTICLE SUMMARY

Article focus

- Infestations with the common bed bug (*Cimex lectularius L.)* have become problematic in many cities.
- No epidemiologic studies currently exist on the mental health impacts of bed bug infestations.
- In this exploratory cross-sectional analysis, we assessed whether bed bug infestations were linked to sleep disturbances and symptoms of anxiety and depression among tenants in Montreal, Quebec.

Key messages

- This study suggests that individuals exposed to bed bugs may be at risk of experiencing sleep disturbance and of developing anxious and possibly depressive symptoms.
- Appropriate control of bed bug is required to manage the situation and its potential health impacts.

Strength and limitations of this study

- The convenience sample presents a risk for selection bias
- There is a possibility of misclassification biases due to self report even though the Cronbach α values calculated from our data showed remarkable consistency with literature values for the original instruments.
- These results~~, although compelling,~~ are cross sectional in nature and follow-up studies are required.

INTRODUCTION

Adult bed bugs are 4-6mm long, oval and flattened insects that feed on human blood. Feeding sessions typically last fifteen minutes and are followed by the departure of the bug toward its harborage site. Once fed, bed bugs do not remain attached to their prey.[1] Bed bug bites, like mosquito bites are associated with local cutaneous allergic reactions.[2] To date, there have been no reports of infectious disease transmission via bed bug bites.[2,3] Bed bugs can be exterminated rapidly but extermination techniques are complex. In some settings bed bug infestation may become chronic.[4]

Anecdotal and historical evidence suggests that infestations by with the common bed bug (*Cimex lectularius* L.) may be a stressor that can cause profound has emotional and psychological effects an emotional and psychological effect.[43] Field workers and pest control managers in Montreal,[52] Toronto,[43] and in 43 countries around the globe surveyed by the NPMA (National Pest Management Association) have observed psychological distress among infested individuals living with infestation.[64] There are reports of people resorting to dangerous methods in order to rid their dwellings of bed bugs,[75] and Rrecently, Goddard and de Shazo highlighted noted that comments posted on bed bug-related websites revealed symptoms of PTSD (Post Traumatic Stress Disorder).[86] However, Nnone of these studies, however, were performed in a clinical setting and there is currently no original published epidemiologic data available on the mental health impact of bed bug infestations. The objective of this study was to conduct an exploratory cross-sectional analysis comparing individuals living with and without bed bug infestations using three standardized clinical mental health measures.

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Data collection and measures

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Statistical analysis

Chi-square analyses were used to distinguish characteristics particular to the bed bug exposed group as compared to the unexposed group. Scores for the three instruments were dichotomized into 'present/absent'. Scores corresponding to symptoms 'present' were: 10 and over on the PHQ-9 out of 27, (moderate symptoms of depression or worse), 5 and over on the GAD-7 out of 21(mild symptoms of anxiety or worse) and 10 and over out of 27 on the PSQI 5th subscale. For any given participant, data from the GAD-7 or PHQ-9 were disregarded if 3 or more items were left blank. Missing values for these scales were replaced with the mean scores of the other subjects items response ~~imputated~~ if the number of missing responses was less than 3.

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consistency of the psychometric tools [GAD-7, PHQ-9 and PSQI(5)]. Analyses were performed using SPSS 12.0.2 for Windows (SPSS 1989-2003).

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Stressful event in last year		
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Psychiatric diagnosis		
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1+	44	9
Medical diagnosis		
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Total		91

* These variables differed significantly for the exposure groups on Pearson Chi-Square analysis $p<0.05$, two-sided test.
** May not total due to missing data.

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	Unadjusted OR [95% CI]	Fully adjusted OR [95% CI]*
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Our study showed that anxiety symptoms and sleep disturbances were significantly more likely to occur among individuals exposed to bed bug infestation~~s~~. The association between exposure and depressive symptoms occurred in the expected direction, but was non-significant at the level of $p<0.05$.

To our knowledge, this study is the first to quantitatively explore the ~~mental health impact~~anxiety symptoms, depressive symptoms and sleep disturbance associated with ~~of~~ bed bug infestations. Literature on ~~the~~anxiety and depressive symptoms and ~~or~~ sleep

disturbance associated ~~mental health effects~~with ~~of~~ infestation ~~with~~ with biting arthropods is scant, but some anecdotal evidence exists that infestation with ~~is available for~~ pigeon fleas[12~~10~~] and headlice can have a negative effect on sleep.[13~~11~~] The dermatologic literature details other pruritic skin conditions such as psoriasis and atopic dermatitis and their consequences on sleep[14 ~~12~~] and mental health.[15~~13~~]

Field Code Changed

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These results~~, although compelling,~~ are cross sectional in nature and follow-up studies are required. A 'pre-post' intervention approach would be appropriate in this situation as there is an ethical imperative to treat the dwellings of patients in addition to their symptoms. Such an approach would allow us to evaluate changes in reported symptoms after the bed bugs have been eradicated in the dwelling and the stressor thus removed.

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CONTRIBUTORSHIP STATEMENT

All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors accept responsibility for the content of this manuscript. The article is not under consideration for publication elsewhere. The authors reviewed this manuscript and all agree that the work is ready for submission. The study was conceptualized and designed by Stephanie R. Susser, Stéphane Perron, Michel Fournier, Louis Jacques, Geoffroy Denis and Pasquale Roberge. The data was acquired by Stephanie R. Susser, Stéphane Perron, Louis Jacques and Geoffroy Denis. Statistical analysis was performed by Stephanie R. Susser, Stéphane Perron and Michel Fournier. The data was analyzed and interpreted by all authors. The manuscript was drafted by Stephanie R. Susser and revised by all authors.

ACKNOWLEDGEMENTS

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Isabelle Mondou gave comments on the study and the manuscript. Nassima Chirane offered comments on the study. Valérie Clayman helped edit the manuscript.

COMPETING INTERESTS AND FUNDING

The work presented in this manuscript was supported financially by ~~institutions~~ the Direction de santé publique de Montréal with no competing interests. None of the authors have any competing interests to declare.

LICENCE FOR PUBLICATION

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FIGURE LEGEND

Figure 1. Algorithm for attribution of a diagnosis of bed bug infestation based on presence of characteristic lesions and environmental evidence

Figure 2. Participant flowchart

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 7 figure 2
		(b) Give reasons for non-participation at each stage	Page 7 figure 2
		(c) Consider use of a flow diagram	Figure 2
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7 table 1
		(b) Indicate number of participants with missing data for each variable of interest	Page 7 table 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	Page 7 table 1
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 8 table 2
		(*b*) Report category boundaries when continuous variables were categorized	Page 6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 10
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

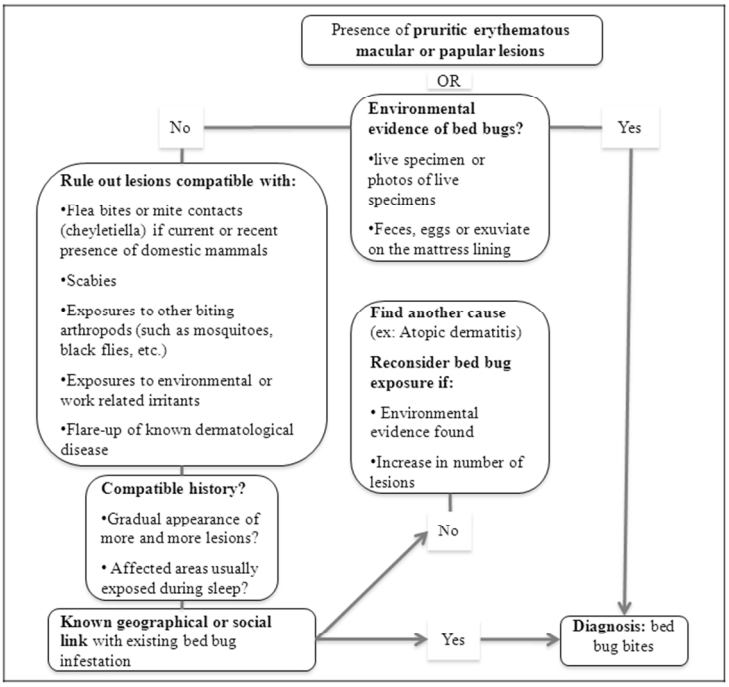

Figure 2: Algorithm for attribution of a diagnosis of bedbug infestation based on presence of characteristic lesions and environmental evidence

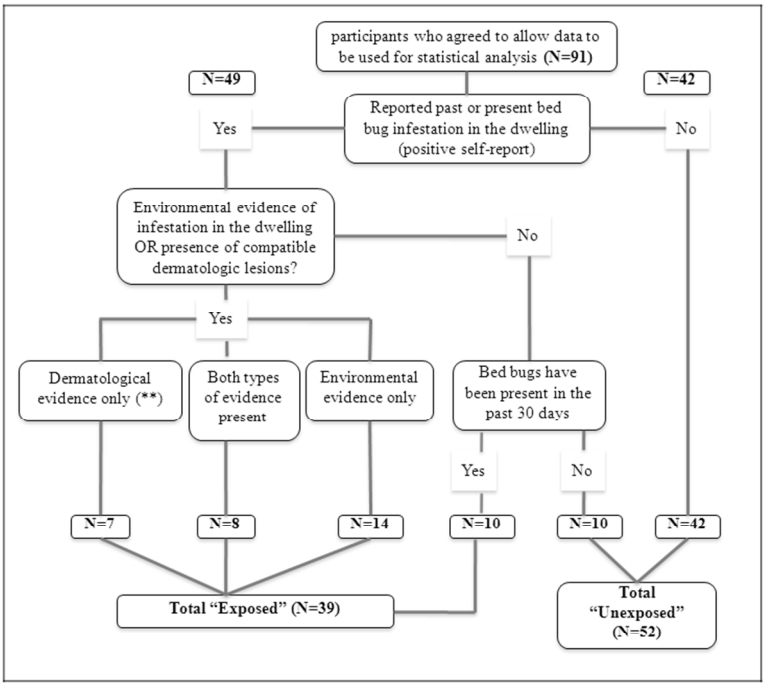

Figure 1: Participant flowchart